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Glove Use and the Relative Risk of Acute Hand Injury: A Case-Crossover Study

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The purpose of this study was to investigate the relationship between glove use and acute traumatic occupational hand injury. We used a case-crossover, within-subject study design to control for differences between individuals such as occupation, injury history, age, gender, risk-taking behavior, manual dexterity, and muscle strength. A total of 1166 hand-injured workers were interviewed regarding the use of gloves at the time of the injury. The self-reported average duration of glove use in the previous work month was the measure of expected exposure to wearing gloves. Nineteen percent of subjects reported wearing gloves at the time of the injury. The expected exposure to glove use in the past work month was 27.9%. Glove use was associated with a lower risk of lacerations and punctures but not crush, fractures, avulsions, amputations, dislocations; the risk of the former two injury types was estimated to be 60–70% lower while wearing gloves. Glove use is only one component of a comprehensive hand injury prevention approach that might include the identification and elimination of sharp hazards, engineering controls, safety warnings, training in high-risk situation awareness, and proper selection and timing of glove use.

Keywords case-crossover, epidemiology, gloves, hand, injury

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Gloves are designed for many purposes: physical protection of the fingers and hand against cuts, punctures, abrasions; barrier protection against chemical permeation or degradation; and heat and flame protection and resistance to cold.[1,2] Gloves are also designed to protect food and other products from skin contact.

Glove use may also have unwanted side effects such as increasing muscle forces to maintain maximal grip,[3] and on occasion may contribute to an injury by being caught in machinery and pulling the hand into a pinch point. Hand injury prevention ultimately depends on engineering and administrative controls, situation awareness, and the use of hand gloves.[4] Too often, some or all of these injury prevention strategies fail to protect workers from acute traumatic hand injury.

In the United States workers with acute traumatic hand injuries account for over 1 million annual emergency department visits in the United States[5] and, according to the Bureau of Labor Statistics (BLS) data, lacerations of the fingers and hand combined are second only to back strain and sprain in the number of days-away-from-work cases.[6] Employers in the United States are required by law to identify hazards to their employees and to have each affected employee use personal protective equipment (PPE) that will protect the employee from identified hazards. Training in PPE use is also required.[7–9]

Glove use has been shown to reduce the risk of an acute occupational hand injury by about 60% in two controlled studies.[10,11] However, in two large studies of acute hand injury at work, 72 and 81% of injured workers reported not wearing gloves at the time of the injury.[11,12]

The aim of this article is to describe the relationship between glove use and acute hand injury in a study of 1166 injured workers. The effects of glove use across occupational category and work task were examined specifically, as well as the location and type of hand injury while wearing or not wearing gloves. Some suggestions for preventing acute hand injuries are also proposed.

METHODS

Study subjects were recruited from 23 occupational health clinics in five northeastern states in the United States. To be eligible for the study subjects must have had one or more of the following types of injury to the fingers, hand, or wrist: laceration, crush, avulsion, puncture, fracture, contusion, amputation, or dislocation, and have sought clinic treatment within 36 hours of the time of the injury. Injuries due only to sudden-onset mechanical energy transfer to the hand were the focus of this study, thus cumulative trauma disorders, sprains/strains, and burns were excluded. The study protocol was approved by the Liberty Mutual Research Institute for Safety Institutional Review Committee and the Harvard School of Public Health Human Subjects Committee.

If the subject agreed to participate in the study, a consent form was signed and a case information form was completed by the treating clinician, including the date and time of the injury, the nature of the injury, and the location of the injury on the hand. The case information and consent forms were faxed to the data-coordinating center. The study subject was called at home outside of the clinic or work setting usually in the evening hours. No information was collected about the subject's employer. The subject was paid $25 for a completed interview.

During a structured telephone interview data were obtained regarding the circumstances of the injury, the occupation, job experience, and common tasks performed. The occupation was coded according to the 1990 *Dictionary of Occupational Titles* using the subject's job title and the three most commonly performed tasks reported by the subject.[13] The subject was asked about his/her work tasks during the 90-min period before the injury excluding any work breaks. Subjects were asked about glove use using the following questions.

1. "Were you wearing gloves at the time of the injury back to 90 minutes before the injury?"
2. If yes, "*When* were you wearing gloves during the 90-minute interval?"
3. "How many times per week or month on average do you wear gloves at work?"
4. "For what length of time on average do you wear gloves at work?"

Questions 1 and 2 were used to assess exposure at the time of the injury. Questions 3 and 4 were asked to determine the average frequency and duration of glove use in the past week or month.

The amount of exposed person-time to glove use in the prior month was estimated as the product of the average number of episodes of glove use and their average duration in min or hours. Estimates of exposure for the week were multiplied by 4.3 or the average number of weeks in a month (52 weeks/12 months). Subjects who reported wearing gloves at the time of the injury were considered exposed in the analysis. For instance, if a subject reported being injured at 10:15 a.m. and reported wearing gloves at the time of the injury, their exposure would coincide with their injury time. Percent of work time wearing gloves was estimated for each individual, taking into account their work hours including overtime. Other transient risk factors at the time of the injury were also assessed including working with equipment, tools or work pieces not performing as expected, using a different work method to do a task, doing an unusual task, being distracted, being rushed, and feeling ill.

Additionally, questions about gloves being required for the task, the type of gloves worn at the time of the injury, and safety training were also asked. The possible role of gloves contributing to the injury was ascertained by reading the self-reported description of how the injury occurred for subjects who reported wearing gloves at the time of the injury. The verbatim text describing the task the subject was performing was also categorized to evaluate the tasks performed while wearing or not wearing gloves.

Reliability of Glove Use Responses

The reliability characteristics of the study questionnaire have been published elsewhere.[14] In brief, 29 subjects were re-interviewed within 4 days of the initial interview regarding the number of hours of glove use in the month before the injury and at the time of the injury. The intra-class correlation coefficient (95% confidence interval [CI]) was 0.91 (0.82–0.96) for reported hours of glove use in the past work-month. The reported agreement beyond chance (Kappa, 95% CI) for reported glove use (yes/no) at the time of the injury was 0.91 (0.74–1.0). All 28 subjects reported being either very confident or certain about the number of hours of glove use in the past month.

Statistical Analysis

Descriptive statistics are presented according to the self-reported use or nonuse of gloves at the time of injury. Continuous variables are presented using the mean ± standard error of the mean and categorical variables are presented using counts and percentages. Statistical comparisons between glove use status at the time of injury for categorical variables (e.g., job experience) were made using Fisher's exact test or a chi-square test of independence, as appropriate. Continuous variables (e.g., age) were compared using a two-sample t-test.

The analysis of the case-crossover data for glove use as a risk factor was conducted using standard methods for stratified analyses.[15,16] In the case-crossover design the individual subject is the stratifying variable. That is, each injured subject acts as his or her own control. We estimated the relative risk and 95% CIs for these highly stratified data using the Mantel-Haenszel estimator for person-time data.[17] Relative risk estimates are based on the ratio of the observed frequency of exposure to glove use at the time of the injury to its expected frequency. The past work-month before the injury was the control-time period selected for this analysis.[18] The average incidence rate ratio (relative risk) refers to the rate of having a sudden-onset hand injury when exposed to glove

use (as a transient risk or protective factor) compared to the rate when unexposed. This estimate is unbiased for follow-up studies with sparse person-time data.[19] Because the time interval under study is very short, the incidence rate ratio can be interpreted as the short-term relative risk of a sudden-onset hand injury. The Appendix demonstrates the relative risk and 95% CI calculation for five hypothetical subjects. Chi-square tests of homogeneity were used to evaluate changes in relative risk estimates across occupational category and injury type.[17]

RESULTS

Between September 1997 and August 2000, 1166 hand-injured workers were interviewed from 23 occupational health clinics in New England. The response rate was 78% of those eligible. The median and mean time interval between date of injury and date of interview was 1.3 and 2.0 days, respectively. Ten percent of subjects were interviewed 5 or more days after the injury date. The mean age (SD) of the subjects was 37 (11.4) years. There were 891 (76.4%) men and 275 (23.6%) women in the study. Seventy-two percent of subjects were employed in either manufacturing (42%), construction (15%), packaging, manual materials handling, or miscellaneous (15%) occupations. The remainder (28%) worked in service, professional, or managerial occupations. The majority of subjects (83.4%) had a single type of injury, most often a laceration (62%), and nearly all were of minor severity according to a hand injury severity scale.[20]

Among all injured subjects with glove use data (n = 1165), 225 (19.3%) reported wearing gloves and 940 (80.7%) reported not wearing gloves at the time of their hand injury (Table I). Subjects were more likely to have gloves on at the time of the injury if they had safety training and worked in a company with less than 50 employees. A total of 925 subjects were asked if gloves were required for the task they were doing at the time of the injury (this question was not asked of all subjects because it was added to a later version of the questionnaire). One-hundred-ninety subjects (20.5%) responded "yes," 720 (77.8%) responded "no," and 15 (1.6%) did not know. Being required to wear gloves for the task increased the proportion of subjects reporting glove use at the time the injury occurred. The proportion of subjects wearing gloves if required was 134/190 (70.5%); if not required, the proportion was 31/720 (4.3%). Lacerations and punctures occurred less frequently than other injury types when subjects reported wearing gloves at the time of the injury. Crush, avulsion, and fractures occurred more frequently with gloves on than without gloves.

Of the 225 subjects reporting glove use at the time of the injury, 171 were asked to identify the type of gloves worn (using data from a later version of the questionnaire). Two categories of glove type (thick 58% and thin 42%) were based on the 168 subjects who responded. Gloves with a combination of materials were categorized based on the first mentioned type of material (e.g., cloth and plastic were categorized as cloth). The thick category was comprised of cotton, cloth, or canvas (54%); leather or suede (42%); or Kevlar or mesh (4%). The thin category included latex (42%), rubber (24%), and plastic or vinyl (24%).

Glove use at the time of the injury, during the control period 1 month before, and the relative risk of hand injury by occupational category is shown in Table II. The percentage of workers wearing gloves at the time of the injury varied by occupational category and was highest for motor freight and food handling occupations and lowest for clerical, sales, and packaging and manual materials handling workers. During the month before the injury the same rankings held, except subjects in bench work occupations wore gloves less frequently on average in the control period. Glove use was associated with a lower risk of hand injury across all categories of occupations as shown by relative risks less than 1.0. There was no significant difference between the relative risks (chi-square test of homogeneity, $p = 0.38$), although gloves appeared to reduce hand injury risk most among structural workers and least among bench work and motor freight occupations. The most commonly co-occurring transient risk factors present while wearing gloves were rushing and working with unusual performing equipment, tools, or work pieces (data not shown).

Glove use was associated with a lower risk of laceration and puncture injuries more than crush, avulsion, amputation, fracture, or dislocation (Table II). The former relative risk was 0.34 (95% CI, 0.27–0.42) compared with 0.93 (95% CI, 0.62–1.39). Chi-square test for homogeneity of these two strata was statistically significant ($p < 0.001$). This finding suggests that while glove use appeared to lower the risk of low energy transfer injuries such as lacerations and punctures, glove use was not associated with a lower risk of sustaining injuries in which the energy transferred to the hand exceeds the physical properties of the glove (e.g. crush injuries).

Use of gloves at the time of injury was analyzed by the type of task the subject was doing when injured (Table III). Considerable variation was seen in the percentage of subjects wearing gloves at the time of the injury according to job tasks. Gloves were worn more frequently when cutting food items (46.6%) than nonfood items (9.7%). Gloves were worn less frequently when repairing or unjamming machinery (12.6%) than overall (19.3%). Subjects doing mechanically-assisted manual materials handling wore gloves more often at the time of the injury (34.4%) than subjects moving materials manually (19.6%). Seven of 225 subjects (3%) wearing gloves said their gloves contributed to the injury.

A subset analysis was run among the 190 subjects who reported being required to wear gloves for the task they were doing when injured. These subjects were cross-classified by the use or nonuse of gloves at the time of the injury and by potential determinants of glove use. Overall, 134 (70.5%) of these subjects reported wearing gloves at the time of the injury. Subjects in food handling were more likely to have gloves on (80.4%) when injured than were machine operators (65.5%). Women, when required to wear them, were more likely to have gloves on than men (80.0 vs. 67.1%). Glove use tended to decrease with increasing job experience. Contrary to

TABLE I. Characteristics of Hand Injured Subjects Reporting Use and Non-Use of Gloves at the Time of the Injury, Northeastern United States (1997–2000)

	Glove Use at Time of Injury					
Characteristics	**Yes**		**No**		**Total**	**p-Value[A]**
Total n (%)	n = 225 (19.3%)		n = 940 (80.7%)		1165	
Age, years						
Mean ± SD	37.1 ± 11.8		37.2 ± 11.4		37.2 ± 11.4	0.94
Median (range)	36.5		36.0		36.1 (18–77)	
	n	%	n	%	n	
Gender						
Male	177	78.7	713	75.9	890	0.43
Female	48	21.3	227	24.1	275	
Race/ethnicity[B]						
White/non-Hispanic	127	74.3	594	78.0	721	0.62
Hispanic	23	13.5	90	11.8	113	
Black/non-Hispanic	11	6.4	48	6.3	59	
Other	10	5.8	30	3.9	40	
Job experience[B]						
<1 year	66	29.3	244	26.0	310	0.39
1–3 years	51	22.7	250	26.6	301	
>3 years	102	45.3	437	46.5	539	
Safety training on task[B]						
Yes	93	54.7	294	39.0	384	<0.01
No	77	45.3	459	61.0	536	
Company size[B]						
<50	86	52.8	298	40.3	384	<0.01
50–249	41	25.2	277	37.5	318	
>250	36	22.1	164	22.2	200	
Gloves required for task[B]						
Yes	134	81.2	56	7.5	190	<0.01
No	31	18.8	689	92.5	720	
Did not know	6		9		15	
Nature of injury						
Laceration	152	55.7	724	64.2	876	0.09
Crush	42	15.4	141	12.5	183	
Puncture	14	5.1	72	6.4	86	
Avulsion[C]	27	9.9	85	7.5	112	
Amputation	4	1.5	12	1.1	16	
Fracture	20	7.3	47	4.2	67	
Contusion	14	5.1	44	3.9	58	
Dislocation	0	0.0	2	0.2	2	
Handedness						
Right	193	85.8	819	87.1	1012	0.50
Left	23	10.2	108	11.5	131	
Ambidextrous	3	1.3	6	0.6	9	
Missing	6	2.7	7	0.7	13	
Task experience						
<1 year	29	17.2	132	17.5	161	0.99
1–3 years	35	20.7	157	20.8	192	
>3 years	62.1	62.1	465	61.7	570	
Job control						
Self-paced	151	89.3	647	85.5	798	0.18
Machine, incentive or quota-based	18	10.7	110	14.5	128	
Hand injury in past year						
Yes	29	17.1	107	14.2	136	0.34
No	141	82.9	645	85.8	786	

[A] p-value based upon a two-sample t-test (age) or based upon chi-square or Fisher's exact test of independence of categorized variables according to subjects use or non-use of gloves at the time of the injury.

[B] Data for one of 1166 subjects were missing for glove use. Total numbers do not add upto 1165 because some questions were added to a later version of the study questionnaire.

[C] An avulsion injury is a tearing away of skin.

TABLE II. Glove Use at the Time of the Injury (Yes/No) During the Previous Month and the Relative Risk of Hand Injury Stratified by Occupational Category and Injury Type

	Number of Subjects	Number (%) Wearing Gloves at Time of Injury	Avg. % of Work Time Wearing Gloves[A]	Relative Risk	95% CI	p-Value[B]
All Subjects	1132	216 (19.1)	27.9 ± 1.0	0.40	(0.34–0.48)	
Occupation						
Machine trades	372	63 (16.9)	24.1 ± 1.7	0.44	(0.32–0.62)	0.38
Structural work	164	35 (21.3)	37.4 ± 2.9	0.27	(0.17–0.41)	
Food handling	142	58 (40.8)	51.2 ± 3.2	0.50	(0.34–0.72)	
Pack. & MMH[C]	105	9 (8.6)	18.2 ± 3.0	0.28	(0.15–0.54)	
Benchwork	102	13 (12.7)	15.8 ± 2.8	0.61	(0.30–1.26)	
Prof. tech man.	85	8 (9.4)	16.5 ± 2.8	0.40	(0.18–0.85)	
Clerical/sales	69	3 (4.3)	8.5 ± 2.2	0.43	(0.15–1.22)	
Misc. other[D]	67	16 (24.0)	35.7 ± 4.6	0.33	(0.16–0.67)	
Motor freight	26	11 (42.3)	48.8 ± 8.0	0.59	(0.23–1.53)	
Injury Type						
Laceration	729	125 (17.1)	—	0.33	(0.26–0.41)	0.0008
Puncture	65	11 (16.9)	—	0.44	(0.21–0.93)	
Crush	58	16 (27.6)	—	0.99	(0.58–1.69)	
Avulsion	53	14 (26.4)	—	0.80	(0.38–1.68)	
Other[E]	38	10 (26.3)	—	0.69	(0.30–1.60)	

[A] Percent of total work time for each individual reporting glove use in the month before the injury, ± standard error of the mean.
[B] p-value for test of homogeneity across categories of occupation and injury type.
[C] MMH = Manual material handling.
[D] Includes nonfood services.
[E] Includes fracture, amputation, contusion, and dislocation.

expectations, subjects who had a previous hand injury in the last year were less likely to have gloves on than those who did not have a previous hand injury (62.9 vs. 72.1%); subjects with safety training were less likely to have gloves on at the time of the injury (68.1 vs. 75.0%) than those without safety training. However, none of these differences were statistically significant at the $p = 0.05$ level, and could be due to chance variation.

TABLE III. Tasks and Glove Use at Time of Injury

	Glove Use				
	Gloves On		Gloves Off		
Tasks	n	%	n	%	Total
Total	225	19.3	939	80.7	1164
Cutting: nonfood task	16	9.7	149	90.3	165
Cutting: food task	55	46.6	63	53.4	118
Opening/closing device with force	10	13.2	66	86.8	76
MMH: moving objects manually	32	19.6	148	80.4	184
MMH: machine assisted	11	34.4	21	65.6	32
Clearing shavings	3	16.7	15	83.3	18
Handling glass, bottles, metal sheets	8	29.6	19	70.4	27
Repairing/unjamming machine	12	12.6	83	87.4	95
Prepping/adjusting machine	9	18.4	40	81.6	49
Operating machine/tool	29	15.9	153	84.1	182
Maintaining machine/part	14	20.9	53	79.1	67
Hammering	2	10.5	17	89.5	19
Installing	7	20.6	27	79.4	34
Stripping/demolition	5	16.1	26	83.9	31
Other tasks	8	11.9	59	88.3	67

The mean hours of glove use in the previous work-month for all injured subjects was also evaluated. There was no difference between men and women in hours of glove use (78.9 vs. 78.5 hours). Injured workers in manufacturing had the lowest number of mean hours of glove use (67.6) compared to construction workers (101.4) and to professional/service workers and manual materials handlers (81.5 and 80.1, respectively). Subjects with safety training had about 5 hours more mean glove use (80.4 vs. 74.5) in the past month than subjects without safety training.

With respect to location of injury with and without gloves, the left hand overall was somewhat more often injured than the right hand (54.3 vs. 45.7%) (Figure 1). The index, thumb, and middle fingers had the highest percentage of injuries. A higher percentage of injuries occurred to the thumbs and back of the left hand and palm of the right hand with gloves off than with gloves on. The location of finger injuries did not appear to be altered by glove use: most injuries were distal (58%), fewer were medial (27%), and fewest were proximal (15%). We found the nondominant hand was injured more often than the dominant hand regardless of being left- or right-handed. That is, right-handed subjects had 55.4% of all injuries to their left hand. Left-handed subjects had 57.3% of injuries to their right hand.

All subjects were asked what they thought led to their injury and what might prevent similar injuries in the future. Few subjects (n = 32) said that the "cause" of their injury was either not wearing gloves or wearing the wrong gloves (2.8%). When asked what would prevent similar injuries in the future, however, 119 subjects (10.2%) said wearing gloves,

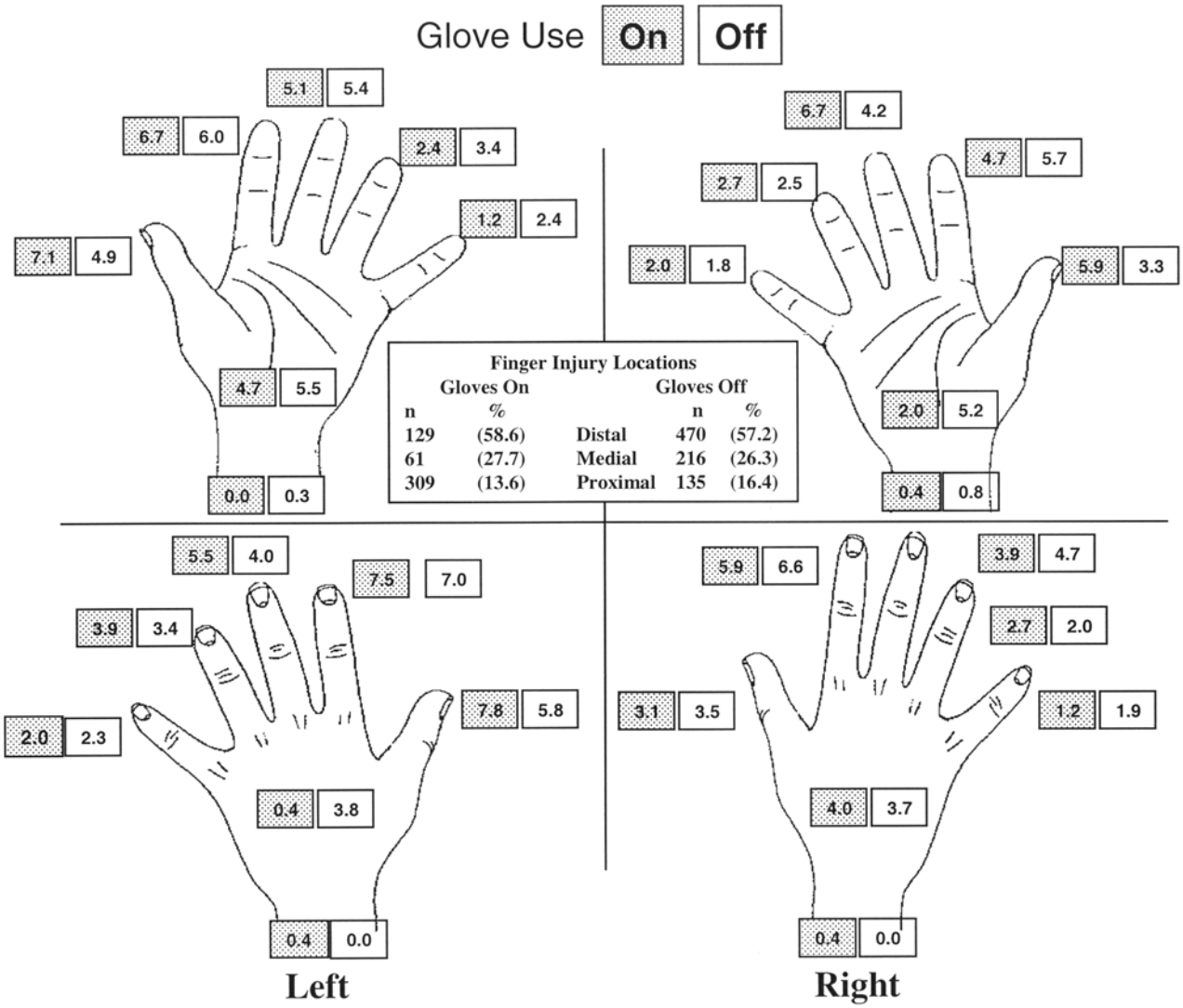

FIGURE 1. Percent of all injury locations by glove use

and another 37 (3.2%) said wearing a different pair of gloves. With respect to other prevention strategies, 10.2% said paying closer attention to the work task, 6.0% said not rushing and doing one thing at a time, 5.2% suggested modifying the machine or work piece to make it safer, or turning the power off. Fifty-five subjects (4.7%) said improvements in housekeeping were necessary, including more space, less noise, or more lighting.

DISCUSSION

The results from this study indicate that glove use is associated with a lower risk of a hand injury across all occupational groups studied. The risk of an acute traumatic hand injury was estimated to be about 60% lower while wearing gloves with a range of plausible risk reduction from 50 to 70%. The lower risk was restricted, however, to laceration and puncture injuries. Subjects were more likely to wear gloves at the time of the injury if they were required, if the subject received safety training on the task, and if the company size was small (<50 employees). Specific tasks in which glove use could be increased include manual materials handling, cutting nonfood items, clearing shavings, and using force to open/close devices. The generalizability of this study should be limited to clinic-based patients employed in similar occupational categories. Although the age, gender, and injury types of the study subjects and the hand-injured clinic population were similar,[20] no data were available on the occupations total clinic-based population of hand-injured patients.

Two other studies examined the role of gloves in occupational hand injury prevention. The first was a BLS survey in 23 states of 944 hand-injured workers with cuts, lacerations, fractures, or burns occurring between January and April 1981 and resulting in one or more days away from work.[12] In that survey, 72% of subjects reported not wearing gloves at the time of their injury compared with 80% in this study. When subjects were asked in the BLS survey why they were not wearing gloves, the responses were: not practical or hard to work with them on (57%), not required to wear them (39%), unsafe to wear gloves for the work being done (23%), did not think they were needed (18%), and not allowed to wear them (12%) (more than one response was permitted). In our study, we did not ask why gloves were or were not worn.

However, requiring workers to wear gloves did significantly increase the reported use of gloves at the time of the injury in our study. Three percent of subjects in the current study said gloves contributed to the injury; in the BLS study, 13% said gloves contributed to the injury. Increased injury severity in the BLS data may account in part for this difference.

The BLS asked explicitly about contribution of gloves to the injury; we relied on the subject mentioning the contribution of gloves to the injury in the verbal description of the event. Glove use in many circumstances will prevent or reduce the severity of an injury, in others they cannot act as a sufficient barrier to the energy being transferred to the hand, especially for injuries resulting in crushes, avulsions, fractures, amputations, or dislocations.

The second study was a case-control comparison of 124 hand-injured municipal workers in Baltimore County, Md., with 124 uninjured workers matched on gender, job, date, and shift.[10] In that study, cuts, lacerations, and punctures comprised 48% of the injuries, sprains accounted for 45%, fractures for 4%, and burns for 3%. All subjects were interviewed by telephone within 8 days of the injury. Consistent with the current study, glove use was associated with a 60% lower risk of a hand injury (odds ratio 0.38, 95% CI 0.14–0.89).

Safety training as part of a larger hand injury prevention approach including proper selection of appropriate gloves seems warranted. For example, latex gloves may not act as a barrier against lacerations but some tightly woven fabric gloves may. Additionally, the type of glove used can be influenced by training and education. One intervention study using information sheets and visual aids was successful in reducing latex glove usage among food handlers from 33 to 3% in 30 small food outlets.[21] Switching glove type to vinyl and polyethylene reduced the risk of allergic reaction among food handlers and possible latex contamination of food.

However, training by itself without reducing sharp exposures by engineering or administrative controls may not be sufficient to reduce injury frequency. In a small study of industrial hand injuries from machinery and training among 39 workers, there was little difference in the time it took to obtain an injury between those with and without training.[22] Training to handle machine malfunctions and identify and avoid human errors may have a greater protective effect than less focused training.[11,23]

While some gloves will afford cut resistance in the work environment, they may also reduce dexterity[24,25] and tactile perception and may increase the forces required to complete a task. There may be some tradeoffs between cut resistance and dexterity. Glove thickness has been associated with reduced peak muscle forces;[3] however, gloves which are designed to provide maximum dexterity may allow comparable torque exertions to the ungloved hand when using nonpowered wrenches and screwdrivers.[26] In another study gloved hands have been shown to afford maximum force and torque to a slippery handle.[27]

Gloves that are snug fitting and comfortable for the worker doing specific tasks may provide the best tradeoff between protective functions and decreased performance. Thus, gloves used for manual materials handling should be selected to reduce the forces needed to perform the task and to be cut resistant. Gloves that have been designed with adequate protection in the zones that need most protection from blunt and cumulative trauma[28] may be the best-integrated approach to future design by glove manufacturers.

Hand glove use is only one aspect of a comprehensive hand injury prevention approach. Analysis based on this set of 1166 injured workers revealed other factors that were associated with a higher risk of hand injury. For example, using unusual performing equipment or materials (e.g., jammed machines or

a newly sharpened knife), performing a task a different way than it is normally done, performing an unusual task, being distracted, or being rushed were all associated with a higher risk of acute traumatic hand injury.[11] Specifically, improvements could be made in machinery maintenance schedules, in training on unjamming equipment, and in greater situational awareness around sharp objects. Other standard approaches may include using best work safety practices and anticipating potential changes in work practices that may increase injury risk. Reduced distractions and rushing may also reduce acute hand injury risk. Wearing gloves at high-risk work times (i.e., when doing a task differently from normal or when doing an unusual task, particularly around sharp objects) may also reduce hand injury risk. In this study, metal items such as nails, metal stock, and burrs accounted for 38.4% of the injuries, followed by hand tools with blades and powered machinery (24.4 and 12.3%, respectively).[20]

An important limitation of this study is recall bias.[29] That is, study subjects may have over- or underreported glove use at the time of the injury, in the control period (the previous workmonth), or at both times. Relative over-reporting of glove use at the time of the injury would have biased our findings toward underestimating the effect of glove use, whereas relative underreporting would bias our findings away from the null. In addition, lack of data on co-occurring exposures in the control period did not permit us to separate the effects of glove use from other risk factors such as doing an unusual task or rushing.

Furthermore, unmeasured within-person confounders such as cigarette smoking or coffee use could also influence the association between glove use and hand injury. However, such within-person confounding would arise only to the extent that these exposures were correlated to the timing of glove use within an individual over time.

In summary, glove use may reduce the risk of laceration and puncture injuries to the fingers and hand in a broad array of occupational settings. Given that laceration injury to the finger is the leading occupational injury treated in U.S. emergency departments, the benefit of providing gloves and training to workers doing high-risk tasks would likely be less than the direct and indirect costs of these injuries to American workplaces. Glove use is only one component of a comprehensive hand injury prevention approach that might include the identification and elimination of sharp hazards, engineering controls, safety warnings, training in high-risk situation awareness, and proper selection and timing of glove use.[30–32]

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APPENDIX

Usual Frequency Analysis Example for Five Hypothetical Subjects Using the Mantel-Haenszel Incidence Rate Ratio (IRR_{MH}): Exposure to Glove Use at the Time of Injury

Subject No.	A_{1_i} Exposed	A_{0_i} Unexposed	T_{1_i} Hrs. Exposed	T_{0_i} Hrs. Unexposed	T_i Hrs. Total
1.	0	1	50	122	172
2.	0	1	75	97	172
3.	0	1	40	114	154
4.	1	0	60	146	206
5.	0	1	45	127	172

The IRR_{MH} is the ratio of the

$$\frac{\text{rate of occurrence of cases in glove-exposed subjects}}{\text{rate of occurrence of cases in non-glove exposed subjects}} \text{ (Ref. 17, p. 270)}$$

$$IRR_{MH} = \frac{\sum_i A_{1_i} T_{0_i} / T_{+i}}{\sum_i A_{0_i} T_{1_i} / T_{+i}}$$

where

A_{1_i} is exposure at the time of the injury (1,0)
A_{0_i} is unexposure at the time of the injury (1,0)
T_{1_i} is amount of person-time in hours exposed in past work-month
T_{0_i} is amount of person-time in hours unexposed in past work-month
T_i is total amount of time in hours at work in past work-month

Incidence Rate Ratio (IRR) =

$$\frac{[(0 \times 122)/172 + (0 \times 97/172) + (0 \times 114)/154 + (1 \times 146)/206 + (0 \times 127)/172]}{[(1 \times 50)/172 + (1 \times 75/172) + (1 \times 40/154) + (0 \times 60/206) + (1 \times 45/172)]}$$
$$= \frac{0.708}{1.248} = 0.56$$

The IRR is interpreted as the relative risk of a hand injury when wearing gloves compared to not wearing gloves. If subjects are never exposed or always exposed they add 0 to the numerator and denominator, respectively.

Variance estimator for the logarithm of the Mantel-Haenszel incidence rate ratio can be found by using the formula on page 270 of Reference 17. The 95% CI for the above IRR estimate is (0.09–3.16).

$$\text{Var}[\text{In}(IR_{MH})] = \frac{\sum_i M_{1_i} T_{1_i} T_{+i}}{\sum_i A_{0_i} T_{1_i} / T_{+i} \sum_i A_{0_i} T_{1_i} / T_{+i}}$$

Where $M_{1_i} = A_{1_i} + A_{0_i}$ is the total number of cases in stratum i.